Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

FURTHER EVALUATION OF THE POTENTIAL STABILITY OF HILTON MINES WASTE ROCK AS CONCRETE AGGREGATE

J.A. Soles
Mineral Processing Laboratory

January 1985

Project MRP-3.6.0.4.56
Performance and Durability of Concrete Incorporating Waste Materials

This document is a [illegible] report [illegible] to [illegible] the [illegible] to Mineral [illegible] (CANMET)

Ce document est un rapport [illegible] révisé et rédigé [illegible] pour fin de [illegible] documentation [illegible] cette [illegible] antérieure de [illegible] canadien de [illegible] des minéraux et de [illegible] (CANMET)

9 pp

MINERALS RESEARCH PROGRAM
MINERAL SCIENCES LABORATORIES
DIVISION REPORT MRP/MSL 85-13 (TR)

MAR 15 1985
MICROMEDIA

FURTHER EVALUATION OF THE POTENTIAL STABILITY OF HILTON MINES WASTE ROCK AS CONCRETE AGGREGATE

by

J.A. Soles

ABSTRACT

Reinforced concrete ties incorporating waste rock from the Hilton Mines waste dump at Shawville, Quebec were examined petrographically to determine if deleterious alkali-aggregate reaction had taken place during three years of exposure to normal weathering conditions of the Ottawa region. No evidence was observed of aggregate instability, reaction products, or destructive processes related to the different aggregate materials. Although the potential long term stability of the aggregates in normal weathering conditions cannot be predicted solely from these brief exposure tests, they do support the earlier contention from petrographic analysis that such aggregate material would be unreactive.

NOUVELLE ÉVALUATION DU NIVEAU DE STABILITÉ POTENTIEL DES AGRÉGATS STÉRILES-BÉTON À LA MINE HILTON

par

J.A. Soles

RÉSUMÉ

Des sections de béton armé comprenant des stériles du terril de la mine Hilton située à Shawville (Québec) ont été soumises à des analyses pétrographiques afin de déterminer si cet agrégat avait réagi aux alcalis délétères après une exposition d'une durée de trois ans aux conditions atmosphériques normales de la région d'Ottawa. Les différents matériaux composant les agrégats n'ont donné aucun signe d'instabilité, n'ont eu aucune réaction et n'ont donné lieu à aucun processus destructif. Bien que la stabilité potentielle à long terme des agrégats exposés à des conditions atmosphériques normales ne puisse être établie uniquement d'après ces brefs essais, les résultats obtenus confirment ce que les analyses pétrographiques avaient permis d'affirmer, à savoir, qu'un matériau pierreux comme celui-ci ne serait pas réactif.

INTRODUCTION

A petrographic evaluation of the Shawville, Quebec, Hilton Mines waste rock as a potential source of concrete aggregate material was made several years ago (1). The study indicated that it would be sound for general concrete applications, based upon the case histories of similar aggregate materials. With the possible exception of one rock type, the waste was considered to be unreactive with the alkalies expected in a portland cement concrete.

Subsequently, the waste rock was incorporated in concrete mixes for testing its stability in natural conditions of weathering and freezing-thawing. The test units were simulated railway ties manufactured with pre-stressed steel inserts, which would be produced if the concrete proved durable. The present study was made to determine whether any deleterious reactions had occurred during the test period.

RESULTS

MATERIALS INVESTIGATED

The samples examined in this study were drill cores from one of the railway ties, obtained for measurement of the compressive strength of the concrete after three years of weathering in the normal atmospheric conditions of Ottawa, Ontario. No external signs of deterioration of the ties were apparent. Petrographic studies were made on three finely ground sections of the concrete cores received.

AGGREGATE COMPOSITION

The producer of the ties used a randomly selected sample of the Hilton waste rock that had been crushed to minus 19 mm (3/4 in.) size. All of the sample was used as aggregate; fine dust was not removed, nor was a proper size grading obtained by screening (2). This combination would allow maximum use of the rock as concrete aggregate, if it proved to be innocuous, and any potentially reactive material would be retained in the test sample.

The general composition of the Hilton waste rock obtained from the earlier study is reproduced in Table 1. In review, the rock sample supplied for that study was a mixture of predominantly granite gneiss and lesser amounts of andesitic trap, quartz-biotite-amphibole schist, talc-serpentine schist and marble.

Table 1. Composition of Hilton Mines Waste Rock Samples

Minerals \ Rock Type	Granite	Andesite, Trap	Biotite-Amphibole Schist	Talc-Serpentine-Mica Schist
	A. Proportions of Minerals (%)			
Potassic Feldspar	5-35	<1	15-20	-
Plagioclase	35-55	20-30	10-5	2-5
Quartz	15-30	5-10	5-10	-
Calcite	2-3	10-15	1-5	25-30
Chlorite/Amphibole/ Pyroxene	3-5	30-60	10-15	<1
Mica	1-5	5-15	30-50	10-15
Serpentine, Talc	-	-	-	40-60
Epidote	0-2	2-5	10-5	5-10
Magnetite, Sulphides	<1	2-3	3-5	8-10
Sphene, Apatite, etc.	<1	1	Negl.	Negl.
*Per cent of Dump	B. Proportions of Rock Types in Drums (%)			
Drum 1 30	80	13	7	<1
Drum 2 65	59	34	4	3
Drum 3 5	40	27	8	25

*Estimate reported by Collings and Buchanan (3)

The average composition obtained from the petrographic analysis of several concrete core sections is given Table 2. The rock types identified were similar to, and their mineralogy as varied as, those determined in the previous study. The proportions of andesitic rock vs amphibole-biotite schist differ noticeably from the earlier collection. Nevertheless, it appears that the material used as aggregate for the ties is representative of the major supply of rock reported to be in the dump (3).

Table 2. Proportions of Rock Types in Concrete Ties

Rock Type	Petrography	Content
Granite	Pink to grey, unaltered, med. to fine grained, hypidiomorphic	51%
Trap	Metamorphosed, dark andesitic; pyrite common	11
Serp-Talc Schist	Locally calcitic and micaceous	15
Amphibole-Biotite Schist	Fresh to chloritized, quartzose, pyrite and magnetite common	18
Limestone (Marble)	C-gr., serpentinous to talcose	3
Pyrite	Fragments from comminuted schist	2

CONCRETE FEATURES

Careful examination of the finished sections of concrete revealed no features of expansion, rupture, or alteration that can be associated with cement-aggregate reactions. No reaction rims are evident on any of the broken aggregate particle surfaces, no secondary reaction products were observed in potential deposition sites such as porous aggregate grain boundaries, and no radiating fractures indicative of expansion stresses in paste surrounding aggregate particles are visible. The only anomalous feature was a relatively weak bond between the paste and the serpentine-talc-carbonate particles; shrinkage rather than expansion appears to have occurred, for rim fractures at the grain boundaries are common. That rock type was the one classified in the previous study as being possibly deleterious.

Concrete Strength

The compressive strength of the three year old ties was measured on three drill cores and compared with the compressive strength obtained earlier on standard test cylinders cured for 7 and 28 days. The data, compiled in Table 3, indicate that the strength of the concrete has increased an average of 20% over the three-year weathering period, despite a probable reduction of specimen strength from a wedging effect of the reinforcement bars lying transverse to the force. It appears that the paste and cement-aggregate bond have not been weakened by a deleterious reaction.

Table 3. Compressive Strength of Aged Railway Tie Concrete

Specimen	Age	Strength, MPa*
Standard Test Cylinder	7 d.	40.11
Standard Test Cylinder	28 d.	45.40
Drill cores 1 and 2 (70x140 mm) (middle section of tie)	3 yr.	(1) 47.40 (2) 51.46
Drill core 4 (95x190 mm) (end section of tie)	3 yr.	56.05

*1 MPa = 145.6 psi

CONCLUSIONS

It is concluded from this petrographic study that the Hilton Mines waste rock used in the concrete ties has not reacted with alkalies of the cement during their three years of exposure to the local weathering conditions. Strength test of the aged tie concrete support this conclusion. The different rock types are apparently stable in the alkaline environment, as the earlier petrographic analysis indicated, and deleterious reaction is still considered unlikely.

The long term durability of concrete containing the aggregate cannot yet be predicted with certainty, however. The shrinkage fractures that apparently form around particular aggregate particles could perhaps cause trouble in moist freezing and thawing, if they developed at all

extensively; also there is a high content of pyrite in the aggregate that could oxidize to sulphate at high temperatures and rupture the concrete by expansion (3). The mineral is usually stable at normal atmospheric temperatures, but the hazard exists. It would be of great value to extend the expansion tests over several years of intermittent measurement, to examine the life potential of concrete using such aggregate material.

REFERENCES

1. Soles, J.A. "Petrographic studies of potential concrete aggregate: Waste rock from Marmoraton and Hilton Iron Mines"; CANMET, Energy, Mines and Resources Canada; Division Report MRP/MSL 76-67 (IR); 1976.

2. Zoldners, N.G. Report of Company consultant engineer, 1984.

3. Collings, R.K., Buchanan, R.M. "Report of visits to Hilton Mines Ltd., Shawville, Que., Marmoraton Mining Company and Armbro Materials and Construction Ltd., Marmora, Ont."; Energy, Mines and Resources Canada, Mines Branch Mineral Processing Division Internal Report MPI 74-21; 1974.

4. Soles, J.A. "Thermally destructive particles in sound dolostone from an Ontario quarry"; CANMET, Energy, Mines and Resources Canada; Division Report MRP/MSL 82-16 (J); 1982.